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Environmental impacts of stormwater management and pollutant discharges

Sarah Brudler, Karsten Arnbjerg-Nielsen, Michael Zwicky Hauschild, Martin Rygaard

Stormwater management systems are necessary to protect people and assets from flooding and pollution, especially in densely built, sealed urban areas. The possible solutions range from underground pipes and basins, where rain water is often handled together with wastewater, to local and multi-functional solutions, e.g. rain beds or retention lakes.

Ideally, these solutions are not only economically, but also environmentally sustainable. Risk assessments are sometimes carried out, e.g. to determine the effect of discharges during extreme events, but they lack a holistic perspective: While pollutants in runoff are one possible source of (local) environmental impacts, the stormwater management system itself is a source of emissions. Raw material extraction, construction, operation, renewal, and disposal all cause environmental impacts at a more regional or even global scale. These impacts can be quantified using life cycle assessment, which on the other hand usually neglects the impacts from local emissions, even though these may potentially be significant. By integrating local emissions into the assessment, we are able to quantify the total environmental impacts of stormwater management solutions.

We have tested the approach using a sub-catchment of Copenhagen. The existing stormwater management system has to be adapted to climatic changes to maintain existing flood safety levels. The environmental impacts from both local and global emissions over a period of 100 years have been quantified using life cycle assessment. The inventory for the assessment is based on an extensive literature research, planning documents and expert interviews.

Here, we focus on the ecotoxicity impacts: The impact over the whole life cycle of the system, excluding local emissions, is 14 mio comparative toxic units (CTU_e). This ecotoxicity impact is mainly caused by the emission of metals. Metals are, however, also important pollutants in stormwater runoff. In Copenhagen, the emission of stormwater pollutants from runoff are found to cause additional impacts of 19 mio CTU_e when discharged directly to freshwater. If the water first infiltrates through soil, the impacts are significantly lower (10 mio CTU_e). The stormwater system itself is passive, and mainly causes impacts during construction, while runoff goes through the system constantly over 100 years, which explains the large difference in impacts. The results are characterized by a high uncertainty, which is caused by large ranges in measured concentrations in literature (up to 5 orders of magnitude). Limiting these uncertainties is the subject of ongoing research.

Our results highlight the importance of including local emission of toxic compounds in stormwater management systems. Often, an increase in global emission, e.g. through the construction of treatment facilities, will lead to reduced local impacts, and vice versa. By taking into account both local and global impacts, stormwater management systems can be optimized holistically to minimize environmental impacts and create more sustainable stormwater management systems.